I. Distance(s) from injection well(s):

WELL NO.	APPROX. DISTANCE FROM 15-18G (FT)	APPROX. DISTANCE FROM 35-18G (FT)
1-18G	750	1,700
2-18G	950	1,950
45WS-18G	1,750	750
84W-13B	2,050	1,100
284WS-13B	2,450	1,450

J. Annotated copies of all lithologic, wire-line and geophysical logs, mechanical integrity tests, etc.:

See Attachment 2 for annotated well logs.

K. Well history:

See Attachment 2 for well histories.

L. Contingency plan for well failures:

One well will be used as the primary injection well, with the other well available as a back-up injector. Wastewater can be diverted to the back-up well up to its maximum rate and pressure.

Depending on the type of well failure, e.g., casing split, cement bond breakdown, etc., appropriate action will be taken to continue injection service within the applicable state, federal and local **~~Regional Water Quality Control Board (RWQCB) waste discharge~~ requirements. In the event of tubing or packer leaks, injection will be suspended until the appropriate section of tubing or packer can be replaced. For pump failure, the pump, motor, or associated electrical system components will be replaced or repaired. If the injection well is unable to be returned to service, abandonment of the failed well and drilling a new injector will be done in accordance with** original P&A Plan and any other activities **applicable regulations and after approval by appropriate regulatory agencies.**

upon well failure ∴ EPA requires notification. the e.g. here reflects upon loss of MI ∴ shut-in and follow regs as def. in 40 CFR 144. ∴ back-up well may be used in most circumstances

M. Corrective/remedial action for improperly abandoned well(s):

None anticipated.

N. Contingency plan for surface spills or equipment failure:

Depending on the type of failure, appropriate action will be taken to continue injection service within the applicable ~~Regional Water Quality Control Board~~

state, federal and local
will shut-in well and notify EPA w/in 24 hrs and provide corrective action plan for EPA approval

~~(RWQCB) waste discharge~~ requirements. If only one well fails, the wastewater can be diverted to the other disposal well up to its maximum rate and pressure.

3. REGIONAL GEOLOGY

A. Regional structural geology:

The project area lies on the western side of the San Joaquin Basin in the southernmost part of the Elk Hills oil and gas field. The structure of the Elk Hills region consists of three major anticlinal structures: the 31S, Northwest Stevens, and 29R anticlines. The site lies along the synclinal axis that forms the Buena Vista Valley on the south flank of the 31S anticline. Attachment 3 shows a schematic geologic cross-section of the southern San Joaquin Basin through the Elk Hills area.

A 3 does not clearly demo. paragraph 3.A.

provide mat'l. which supports this description of str. geol.

B. Regional stratigraphy:

The regional stratigraphy of the Elk Hills area consists of a thick section of sedimentary rocks ranging in age from Cretaceous to Recent. Miocene marine sedimentary rocks are overlain by a Pliocene sequence that represents the transition to near-shore and brackish water environments. The Pleistocene Tulare Formation consists of a non-marine section, primarily alluvial and fluvial sedimentary rocks. A generalized stratigraphic column of the Elk Hills area is shown in Attachment 4.

C. Seismic activity: (see discussion from C.U.R.E.)

Southern California experienced 19 major earthquakes from 1852 to 1993, ranging in Richter scale magnitudes from 5.9 to 8.0 (Foster Wheeler Environmental Associates, 1999). The largest recorded earthquake in the region was a Richter magnitude 7.7 in 1952. The Wheeler Ridge earthquake was a magnitude 5.2 event in 1993. The Ridgecrest earthquake occurred in 1995 and was a magnitude 5.4. Both events caused little structural damage.

No historically active faults occur in the Elk Hills area, but minor faults have been mapped in the field (Foster Wheeler Environmental Associates, 1999). The San Andreas Fault lies about 12 miles west of the field in the Temblor Range. Other major faults include the White Wolf fault and the Pond-Poso fault, which are located about 25 miles southeast and 22 miles northeast, respectively.

need careful analysis of local faulting see C.U.R.E.

The California Uniform Building Code (UBC, Section 2312) defines the area where Elk Hills is located as a seismic Zone 4 area, which is the highest potential on a scale from 0 to 4 (Foster Wheeler Environmental Associates, 1999). This category requires structural design considerations to protect buildings and other structures from earthquake effects.

4. HYDROGEOLOGY OF CONFINING ZONE FOR PROPOSED AND EXISTING WELLS

A. Formation:

Tulare clay in the upper Tulare Formation.

B. Age of confining zone:

Pleistocene.

C. Thickness of confining zone: why the outcrop? how will it affect as seal? see also CURE.

The thickness of the confining zone in the area of the proposed well locations is about 80 ft (Attachment 5).

D. Mineralogy and lithology of confining zone:

The Tulare clay consists primarily of buff to grayish tan, hard silty clay. Minor interbeds of silt, sand, and gravel may occur in the unit (Milliken, 1992).

E. Structure of confining zone (faults and extent, fractures):

The local structure of the confining zone consists of a west- to northwesterly-trending synclinal axis, which lies along the south-dipping flank of the 31S anticline. No faults appear to occur in the area of review. A structure contour map on the base of the Tulare clay is included as Attachment 6.

F. Stratigraphy of confining zone:

The Tulare clay in the upper Tulare Formation is a Pleistocene, non-marine deposit and primarily lacustrine in origin (Bechtel Petroleum Operations, Inc., 1995; Milliken, 1992; WZI, 1988) (Attachment 7).

G. Description of vertical and lateral continuity of confining zone within a minimum one mile radius of the proposed injection well):

The Tulare clay appears to be areally extensive, with good continuity both laterally and vertically, as shown on an isochore map of the confining zone (Attachment 6) and in cross-sections (Attachment 8).

H. Hydrogeologic parameters of the confining zone:

1. Hydraulic conductivity or permeability (horizontal and vertical):

Core data from the Tulare clay in the area of review was unavailable. However, permeability of the confining zone was estimated to be 44 md based on core samples in clays and siltstones within the upper Tulare Formation in Unit Operator (UO) Naval Petroleum Reserve (NPR) No. 1 46WD-7G. The estimate was calculated using the geometric mean of permeabilities from six conventional core samples. Quantitative analyses of cores from UO NPR No. 1 46WD-7G are included in Attachment 9.

Specify: Need logging program; core program?; test formation fluids above Tulare Clay (see USDW GURE.) (see #6 pg 10)

2. Porosity:

Core data from the Tulare clay in the area of review was unavailable. However, porosity of the confining zone was estimated to be 32% based on conventional core analyses from clays and siltstones within the upper Tulare Formation in UO NPR No. 1 46WD-7G. The porosity estimate was calculated using the arithmetic mean of porosities from six core samples (Attachment 9).

3. Compressibility:

Compressibility of the confining zone is estimated to be 3.4×10^{-6} psi^{-1} based on compressibility values for consolidated sandstones with porosity of 26% at a lithostatic pressure of 0.75 psi/ft (Craft and Hawkins, 1959).

5. HYDROGEOLOGY OF INJECTION ZONE FOR PROPOSED AND EXISTING WELLS

Need to know of other inj. wells w/in same zone.

A. Formation:

Sands and gravels of the upper Tulare Formation.

B. Age of injection zone:

Pleistocene.

C. Thickness of injection zone:

Average gross thickness in injection zone = 1,200 ft. Approximate net sand thickness in injection zone = 750 ft. An isochore map of the net sand thickness of the injection zone is provided in Attachment 10. Annotated well logs that show the gross thickness of the injection interval in the area of review are included in Attachment 2.

D. Mineralogy and lithology of injection zone:

The upper Tulare sands generally are very clean and well sorted and contain minor gravel. Sand beds commonly are interbedded with gravels (Milliken, 1992).

E. Structure of injection zone (faults and extent, fractures):

The local structure consists of a west-northwesterly-trending synclinal axis, which lies along the south-dipping flank of the 31S anticline. No faults appear to occur in the area of review in the injection zone. The structure at the top of the injection zone is shown in the base of Tulare clay structure contour map (Attachment 6). The structure of the base of the injection zone is shown in Attachment 11, which is a map of the top of the Amnicola clay.

F. Stratigraphy of injection zone:

The upper Tulare Formation is an alluvial and/or fluvial deposit consisting of interbedded gravels, sands, silts, and clays. See Attachment 7 for a type log.

G. Description of vertical and lateral continuity of injection zone within a minimum one mile radius of the proposed injection well:

does upper Tulare outcrop similarly to Tulare clay?

Sands in the upper Tulare Formation appear to have good lateral and vertical continuity, as shown in an isochore map of the injection zone (Attachment 10) and in cross-sections (Attachment 8).

H. Hydrogeologic parameters of injection zone

1. Hydraulic conductivity or permeability (horizontal and vertical):

   Permeability of the injection zone is estimated to be 3,757 md. The estimated permeability is based on the geometric mean of 37 cores from sands in the upper Tulare Formation from UO NPR No. 1 46WD-7G.

2. Porosity:

   Porosity is estimated to be 34% based on the arithmetic mean of core data from sands in the UO NPR No. 1 46WD-7G.

3. Reservoir pressure:

   261 psi based on UO NPR No. 1 well 45WS-18G; top of perforations at 974 ft.

4. Storage coefficient:

The storage coefficient, S, of the injection zone is 0.00046.

S = (0.34) * (0.433 psi/ft) * (750 ft) * [(3 x 10-6) +(3.4 x 10-6) *(0.34)] = 0.00046

5. Compressibility:

Compressibility of the confining zone is estimated to be 3.4×10^{-6} psi^{-1} based on compressibility values for consolidated sandstones with porosity of 26% at a lithostatic pressure of 0.75 psi/ft (Craft and Hawkins, 1959).

6. Transmissivity:

Estimated transmissivity = 13.3 ft/d * 750 ft = 9,992 ft^2/d = 74,741 gal/d/ft

7. Formation fracture pressure: see pg 13: .435 psi/ft injectate/form wtr.

Well 15-18G: **498 psi, based on 0.8 psi/ft at top of perforations at 623 ft without friction loss.**
229 psi for surface fracture pressure without friction loss.
- 103 psi : 0.6 psi/ft : 20% Safety factor (pg 23) ⇒ 82 psi

Well 35-18G: **456 psi, based on 0.8 psi/ft at top of perforations at 570 ft without friction loss.**
209 psi for surface fracture pressure without friction loss.
- 91 psi : 0.6 psi/ft : 20% safety factor (pg 23) ⇒ 75 psi

will Allow NO? Default F.G.?

Based on Division of Oil, Gas, and Geothermal Resources (DOGGR) fracture gradient of 0.8 psi/ft for the 18G area of the Elk Hills field (R. White, DOGGR, personal communication, September 14, 1999). Surface injection pressure neglects friction losses. Zone has hi perm. ; almost 1200 inj. interval ∴ step rate test may start at low steps w/sophisticated monitoring → must avoid repeat of Anadime

8. Depth of injection zone:

About 618 ft in proposed injection well 15-18G and about 565 ft in proposed injection well 35-18G.

9. Proposed perforation or screen interval (depth) within the injection zone:

About 623 ft to 1,797 ft in proposed injection well 15-18G. About 570 ft to 1,800 ft in proposed injection well 35-18G (Attachment 12).

6. FORMATION WATER

EPA req. samples & testing at location of ~~first~~ one well

Attachment 13 contains a table of geochemical water analyses of Tulare formation water from water source wells UO NPR No. 1 45WS-18G and UO NPR No. 1 284WS-13B, which are located about 0.75 miles east and west, respectively, of the proposed injection wells. The table provides the average concentrations of groundwater constituents analyzed in 1993 within the injection zone of the two wells nearest to the proposed disposal area (Bechtel Petroleum Operations, Inc., 1995). The screened intervals in 45WS-18G and 284WS-13B are shown on the casing diagrams in Attachment 2.

A. Total Dissolved Solids (TDS):

Average TDS concentrations for 1993 range from 4,485 mg/l in UO NPR No. 1 43WS-13B to 6,142 mg/l in UO NPR No. 1 45WS-18G (Attachment 13; Attachment 14).

B. Analysis of representative formation water sample to include trace elements and priority pollutants (EPA methods 624, 625, and metals):

Attachment 13 provides analyses of a representative sample of formation water commingled from water source wells in Sections 13B, 14B, and 18G. The sample was collected at the OEHI 33S water plant to represent the average formation water in the Tulare injection interval. Open Tulare intervals in the water source wells within the area of review are included on the casing diagrams in Attachment 2.

C. Description of sampling and analytical procedures:

Representative samples were collected using standard quality assurance/quality control (QA/QC) procedures in accordance with EPA SW-846 methodology. A third-party laboratory analyzed the samples within the allowable holding times using EPA-approved methods.

D. Direction and rate of regional groundwater flow:

Regional groundwater maps of "shallow groundwater" and the "unconfined aquifer" by the Kern County Water Agency (1998) are included in Attachment 15. No shallow groundwater was mapped in the project area by the Kern County Water Agency.

The groundwater in the Section 18G area was analyzed and mapped using site-specific groundwater data from geophysical well logs, well file information, and